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User Information Fusion Decision Making Analysis with the C-OODA Model

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Abstract *–For pragmatic information fusion system design and analysis, the user (commander or operator/analyst) needs information in a timely manner to conduct actionable intelligence. With the development of complex information fusion systems, the user still provides valuable inputs to the information fusion system in contextual reasoning and situation understanding. In this paper, we describe the Cognitive Observe-Orient-Decide-Act (C-OODA) model as a method of user and team analysis in the context of the Data Fusion Information Group (DFIG) Information Fusion Model. From the DFIG model [as an update to the Joint Directors of the Lab (JDL) model], we look at Level 5 Fusion of "user refinement" in the context of timely decision making. Using control theory, we present an example of user timeliness assessment in an information fusion decision making model analysis. We model the information input delays in reaching a decision and the action output delays in executing the decision. The C-OODA comparisons to the DFIG model support systems evaluation and analysis as well as coordinating the time interval of interaction between the machine processing (e.g. information fusion) and user processing (e.g. perception and reasoning).*

Keywords: *Decision Support, C-OODA, Level 5 Fusion*

1 Introduction

Models (e.g. control models) can represent a system to determine what is happening, the parameters of interest, and methods for prediction. Models that incorporate man and machine systems are useful for determining who should interact with the system, what interfaces should be designed, where in the process should the user interact, which control actions to perform, and how to better the system.[1] System design analysis, while general for all systems, is important to the information fusion (IF) community.[2] Information fusion systems (IFSs) seek to reduce the enormous amount of data into actionable intelligence for user's to act upon.[3] Numerous literature contributions of process modeling of IFSs have been conducted to clarify user importance in IFSs design.

One of the premier models for user decision-making is the Extended OODA model (Boyd), as shown in Figure 1.

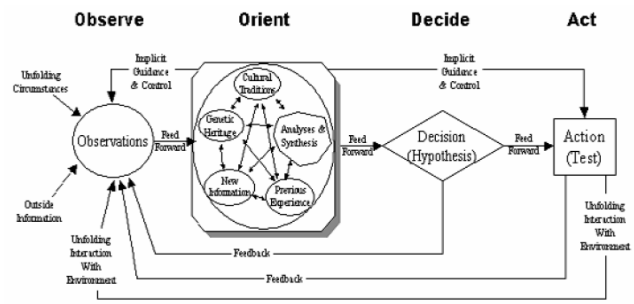

Figure 1. The extended OODA loop.
(Fadok, Boyd & Warden, 1995). [4]

The OODA loop model (Observe-Orient-Decide-Act) has been widely used to represent decision-making (DM) in military environments. The OODA applications for user modeling include information fusion [5], military systems [6], target recognition [7], cultural modeling [8], and recently, semi-automated decision making. [9]

However, the classical or extended versions of the OODA loop suffered from a lack of details to sufficiently support the design of systems. For instance, the model depicted in Figure 1 proposes a more detailed version of the orient process to the detriment of the others. Key to the developments and instantiations of the OODA models include: application relevant decision-making based on context, time of analysis, and uncertainty analysis.

In most military documents, the OODA loop is often referred to as a simple representation of control processes. Because of the simplicity of its representation, the loop offers few details to describe how human makes decision in complex and dynamic C2 environments. This lack of details led to the development of several OODA model versions for different applications. The developments include the modular M-OODA [10, 11], team T-OODA [12, 13, 14], cognitive C-OODA [15, 16] and the Technology, Emotion, Culture, and Knowledge TECK-OODA [8]. For each OODA loop model proposed, there are strong parallels between the OODA model structure and the information fusion models. A comparison of the OODA model to the other information fusion models was analyzed in relation to the Omnibus model [17].

The Data Fusion Information Group (DFIG) model was an update to the Joint Director Laboratories (JDL) model [18] as per meeting in 2004. [2, 19] In terms of the DFIG Information fusion model, *Observe* is Level 1 fusion of

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14. ABSTRACT
For pragmatic information fusion system design and analysis, the user (commander or operator/analyst) needs information in a timely manner to conduct actionable intelligence. With the development of complex information fusion systems, the user still provides valuable inputs to the information fusion system in contextual reasoning and situation understanding. In this paper, we describe the Cognitive Observe-Orient-Decide-Act (COODA) model as a method of user and team analysis in the context of the Data Fusion Information Group (DFIG) Information Fusion Model. From the DFIG model [as an update to the Joint Directors of the Lab (JDL) model], we look at Level 5 Fusion of ?user refinement? in the context of timely decision making. Using control theory, we present an example of user timeliness assessment in an information fusion decision making model analysis. We model the information input delays in reaching a decision and the action output delays in executing the decision. The C-OODA comparisons to the DFIG model support systems evaluation and analysis as well as coordinating the time interval of interaction between the machine processing (e.g. information fusion) and user processing (e.g. perception and reasoning).

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object assessment, Orient is Level 2 fusion of situation assessment. Both Observe and Orient have also been referred to as situation awareness. *Decide* is Level 5 fusion of user refinement and *Act* is level 4 fusion of process refinement. Act and decide are considered decision-making functions.

In military environments, executing the OODA loop faster than the adversary is central to gain advantage in the confrontation.[4] Consequently, the timing between the user and the information system is critical. The objective of this paper is to use the cognitive version of the OODA loop, C-OODA, to develop a control process model to coordinate the timeliness of decision making (DM) between the user and the information fusion evidential reasoning machine. There are two advantages of the C-OODA: 1) it provides high level details on the cognitive processes involved in complex and dynamic DM performed in Command and Control (C2) environments; and 2) it includes in each of its modules a criteria-based (e.g. time and uncertainty) control process that is central to our objective of simulating the timeliness of DM between the user and the information fusion system. User modeling with an IF system is complex. We begin in Section 2 by exploring user-machine decision-making IF models with a summary in Table 1. Section 3 overviews the developments of the C-OODA model. Section 4 provides a notional simulation to characterize the user response times in a cognitive IF decision-making task and Section 5 concludes the analysis.

2 Decision Making Models

2.1 Data Fusion Information Group (DFIG)

A useful model is one which represents a real world system instantiation. The Information Fusion (IF) community has rallied behind the DFIG process model (that replaces the JDL model) with its revisions and developments, shown in Figure 2 [2].

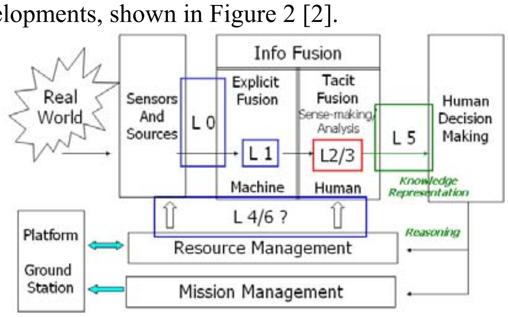

Figure 2. DFIG User-Fusion model [2].

Management functions are divided into sensor control, platform placement, and user selection to meet mission objectives. Level 2 (SA) includes tacit functions which are inferred from level 1 explicit representations of object assessment. Since the unobserved aspects of the SA cannot be processed by a computer, user knowledge and reasoning is necessary. Current definitions, [2], include:

<u>Level 0 – Data Assessment</u>: estimation and prediction of signal/object observable states on the basis of pixel/signal level data association (e.g. information systems collections);

<u>Level 1 – Object Assessment:</u> estimation and prediction of entity states on the basis of data association, continuous state estimation and discrete state estimation (e.g. data processing);

<u>Level 2 – Situation Assessment:</u> estimation and prediction of relations among entities, to include force structure and force relations, communications, etc. (e.g. information processing);

<u>Level 3 – Impact Assessment:</u> estimation and prediction of effects on situations of planned or estimated actions by the participants; to include interactions between action plans of multiple players (e.g. assessing threat actions to planned actions and mission requirements, performance evaluation);

<u>Level 4 – Process Refinement</u> (an element of Resource Management): adaptive data acquisition and processing to support sensing objectives (e.g. sensor management and information systems dissemination, command/control).

<u>Level 5 – User Refinement</u> (an element of Knowledge Management): adaptive determination of who queries information and who has access to information (e.g. information operations) and adaptive data retrieved and displayed to support cognitive decision making and actions (e.g. human computer interface).

<u>Level 6 – Mission Management</u> (an element of Platform Management): adaptive determination of spatial-temporal control of assets (e.g. airspace operations) and route planning and goal determination to support team decision making and actions (e.g. theater operations) over social, economic, and political constraints.

2.2 Observe, Orient, Decide, Act (OODA) Loop

Clearly, a mapping between the DFIG model and the OODA loop cyclic process can be made as shown in Figure 3. The traditional information fusion *data processing* functions (i.e. estimation) include: observe and orient which compose situation awareness. Numerous efforts have sought to model the evidence accumulation in providing a situational analysis including: perception of situations[20], presentation of object assessments[21], descriptions of situations [22], architectures of situational awareness[23], and user assessment of situations [24]. In duality, the information fusion *action* functions (i.e. control) include decide and act as the decision making processes. Examples of information fusion action analysis includes: decision making [25], user refinement [26], and sensor management [27].

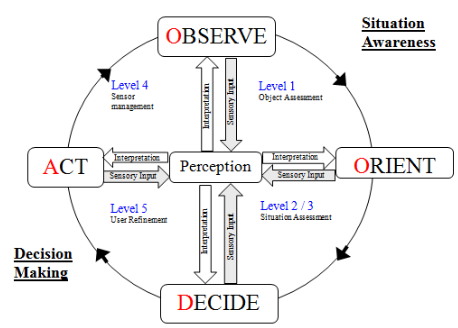

Figure 3. The OODA in relation to the DFIG model.

The OODA phases are: [8]

- *Observe*: A user/organization interacts with the environment, typically by controlling sensors, querying information needs, and assimilating observations from a display.

- *Orient*: A user/organization distills information from data to determine situational understanding through assessment of the environment to determine a coherent state of affairs.
- *Decide*: User engages situational knowledge derived from orientation to prioritize and select plans/results.
- *Act*: The user/organization engages in a process plan that satisfies current needs.

The OODA and DFIG models have similar properties in trying to capture the decision process. When the user must reason over an enormous amount of data for a contextual situation, cognitive analysis is required for mission success. Cognitive models include the developments from physiology [28], decision support, [29, 30] automation [31], to high-level information fusion [32]. Table 1 relates the relevant information fusion decision making models.

Table 1: Comparisons of Decision Making Models.

Activity	DFIG Model	Omnibus Model	OODA	C-OODA
Command Execution	Level 6	Resource Tasking	Act	Action Implementation
Decision Making	Level 5	User Control	Decide	Recall Evaluate
Sensor Management	Level 4	Decision Making		
Impact Assessment	Level 3	Context Processing	Orient	Projection
Situation Assessment	Level 2	Pattern Processing		Comprehension
Object Assessment	Level 1	Feature Processing		Feature Matching
Signal/Info Processing	Level 0	Signal Processing	Observe	Perception
Data Acquire Registration		Sensing		Data Gathering

2.3 Multiplayer OODA

Figure 4 shows the time window associated with multiple decision makers (DMs) (user and adversary). Given an operator and an adversary, we must address the differing response times associated with action.

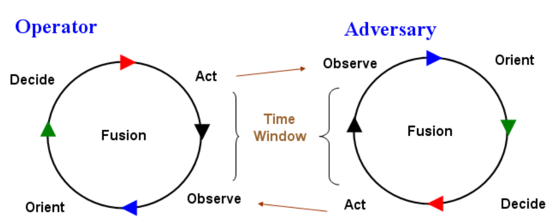

Figure 4. Operator and adversary OODA loops with the associated time window to act.[7]

As an example of differing action cycles, Figure 5 shows the case for the need for rapid decision making. On the left, if the user reacts to immediate threats, where the adversary has already been able to attack. If the proactive strategy is used and sensed information details anticipated events, the user could inter potential threats from occurring. Finally, on the far right, if the OODA loop (sensing and processing combined with behavior analysis) provides the user with *a priori* information. In this scenario, it would allow the user to act very quickly to prevent actions from occurring. To model the OODA cycle, a queuing analysis was used to determine the prevention and proactive protection and results are in [7].

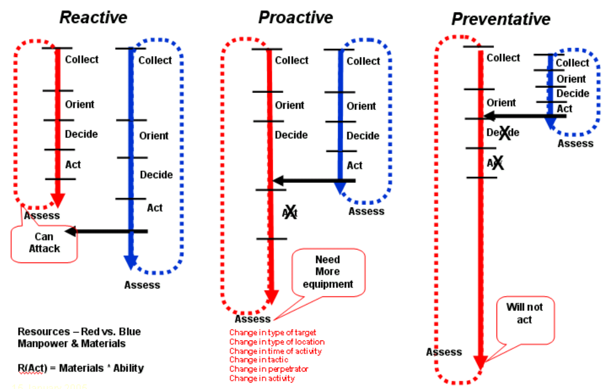

Figure 5. Progression from reactive to preventative event chains with OODA process loops.[7]

3 The Cognitive OODA Loop

Repeated attempts at modeling C2 reflect the importance of such modeling for understanding C2 and contributing to the design of support tools and training efforts aimed at an improvement of C2.

Describing the C2 cycle usually involves *descriptive models* which divide the task into processes [33] such as the Stimulus, Hypothesis, Option, Response (SHOR) model by Wohl. Mayk & Rubin [34] provide a systematic analysis of C2 descriptive models. Comparatively, *prescriptive models* are theory driven and are used to develop software for decision support.

To develop the C-OODA, some classical and well-accepted models have been used to increase the cognitive granularity of the OODA loop. For instance, Breton [11] used the Situation Awareness (SA) model proposed by Endsley [35-36] to model the Observe and Orient phase and the Recognition-primed Decision model (RPD) of Klein [37-38] for the Decide and Act phases.

3.1 Situation Assessment Models

Situation assessment is an important concept of how people become aware of things happening in their environment. SA is defined by *HQ USAF AFISC/SE Safety Investigation workbook* as "keeping track or prioritized significant events and the condition's in one's environment". Level 2, Situation Assessment is the estimation and prediction of relations among entities, to include force structure and force relations, communications, etc. which requires adequate user inputs to define entities.

3.1.1 Situational Awareness Model

The Human in the Loop (HIL) of a semi-automated system must be given adequate SA. According to Endsley "SA is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." [35] This now-classic model, shown in Figure 6, translates into 3 levels:

- Level 1 SA - Perception of environmental elements
- Level 2 SA - Comprehension of the current situation
- Level 3 SA - Projection of future states

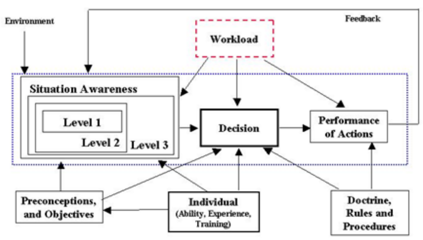

Figure 6. Endsley's Situation Awareness Model.

Operators of dynamic systems use their SA in determining their actions. To optimize decision making, the SA provided by a Data Fusion System (DFS) should be as precise as possible as to the objects in the environment (Level 1 SA). A SA approach should present a fused representation of the data (Level 2 SA) and provide support for the operator's projection needs (Level 3 SA) in order to facilitate operator's goals. From the SA model, workload is a key component of the model that affects not only SA, but also the decision and reaction time of the user. [36] To develop the SA model further, we note that the user must be primed for situations to be able to operate faster, and more effectively.

3.1.2 Recognition Primed Decision Making Model

To understand how the human uses the situation context to refine the SA, Breton [11] uses the RPD model [37, 38]. The RPD model develops the user decision making capability based on the current situation and past experiences. The RPD model shows the goals of the user and the cues that are important. The RPD model allows us to capture the *reduction in reaction time* and *increase in accuracy* for the cases in which the user cues the DFS and when the DFS cues the human. According to Breton [11] some parallels between the processes included in the RPD and SA models can be made as shown in Figure 7.

The user must present the priority of information needs to the DFS. The information priority is related to the information desired. The user must have the ability to choose or select the objects of interest and the processes from which the raw data is converted to the fused data. One of the issues in the processing of fused information is related to ability to understand the information origin or pedigree. To utilize the information priority list, Blasch [6] used the SHOR model to detail IF functions.

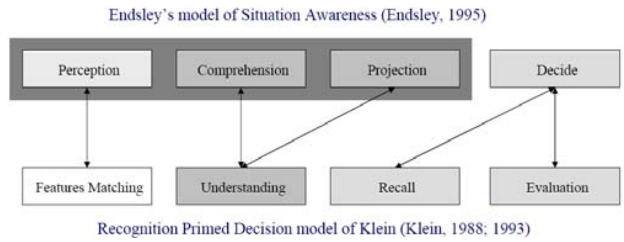

Figure 7. Comparison of SA and RPD models. [11]

3.1.3 SHOR model for Action

To determine how to model the user cognitive decision/action cycle, we can use information from the *Judgment and Decision Making* community. [39] Simon [40] looked at the analysis as a function of: Intelligence, Design and Choice. Huber [41] listed the process as a 5 steps function including (1) Problem Identification, (2) Problem Definition, (3) Problem Diagnosis, (4) Generate Alternatives and (5) Evaluate and Selection. Finally, Wohl [42] developed the SHOR model (Table 2) for military tactical decision making. In the C-OODA model, we are interested in how the user can constrain (i.e. *problem diagnosis)* the data as well as be cued by the IFS for decision and action. If we adapt the SHOR model for fusion systems, we have a representation for the hypothesis space for C-OODA comprehension and evaluation.

Table 2: The SHOR analysis of the User-Fusion system

	Process	Element	DFIG Cat.	Level
Stimulus (Data)	Gather / Detect	**Machine**	**Object**	**1**
	Filter / Correlate	Machine	Object	1
	Aggregate / Display	Machine	Situation	2
	Store / Recall	Machine	Sensor Mgt	4
Hypothesis (Perception Alternatives)	Create	**Human/Mach**	**User/Object**	**5/1**
	Evaluate	Machine	Situation/Imp	2/3
	Select	**Human**	**User**	**5**
Option (Response Alt)	Create	Machine	Impact	3
	Evaluate	**Machine**	**Imp/User**	**3/5**
	Select	**Human**	**User**	**5**
Response (Action)	Plan	Machine	Sensor Mgt	4
	Organize	Machine	Sensor Mgt	4
	Execute	**Human**	**User**	**5**

*Far right column is the Levels in the DFIG model

We see that the user plays a large part in the process of determining IFS actions. The SHOR model can be developed further to include the processing levels of the IFS so as to determine the levels of interaction between the user and the IFS. From Table 2, we see that many interactions between the IFS occur between levels 2-3, and 5. Such an example is determining relevant cues from the environment for decision making as per the C-OODA.

To analyze the C-OODA domain-relevant actions, we could employ a cognitive work analysis (CWA) [43] to determine the amount of actions needed over a specified time period. Suchman [44] developed a concept for situated action, which can be used for known situations, however when the situation is unknown, the user needs to integrate information for situation understanding (SU).

The Modular OODA (M-OODA) provides a decomposition of control processes for SU to action.

3.2 The Modular OODA (M-OODA)

The M-OODA incorporates explicit control and flow modular components with the current understanding of military C2 as shown in Figure 8. [11] A module operates as a simple control system with inputs, outputs, and processing times that are not sequential but rather iterative between modules. The control flow follows from a state diagram at each of the modules and can be analyzed as a whole or separately. The M-OODA model modifies the OODA loop based on the following principles:

1) It adopts a modular, approach in which each process of the OODA loop is represented as a generic module structured around three components: Process, State and, Control;
2) It incorporates explicit control elements within and across modules enabling a bidirectional data/information flow and feedback between modules;
3) It provides a basic architecture for modeling a variety of team decision-making in with the OODA loop.

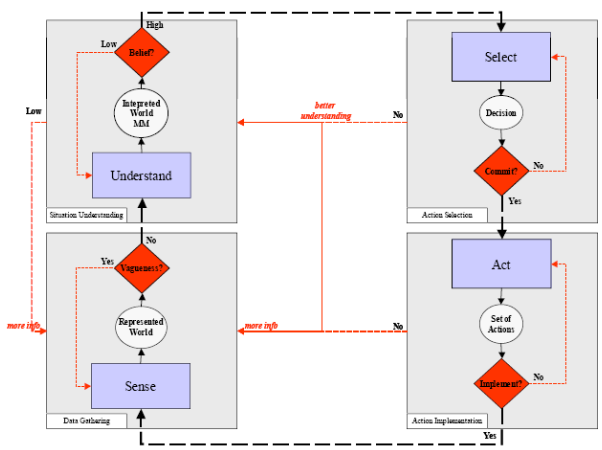

Figure 8. M-OODA Control modeling.[11]

To utilize the OODA concept in a C2 system, elements of the modules include: Data gathering (Observe), situational understanding (orient), action selection (Decide), and action implementation (Act).

Table 3: Specifications M-OODA components.[5]

Module	**Process**	**State**	**Control**
Data Gathering	Sense, encode, register, data translation, transduce, scan, fuse, detect, monitor	World representation, , scene organization, multimodal integration	Vagueness, completeness, fuzziness, time available, quality of picture
Situation Understandin g	Understand, ID, categorize, classify, organize, recognize, form hypothesis, schematize,	Mental model, schema, episode, familiarity estimation	Belief in interpretation, familiarity of schema, uncertainty on meaning
Action Selection	Select, choose, identify options, apply rules, consult,	Decision, list of actions (course of actions), risk evaluation, expected gain, selection rules	Risk analysis, completeness of options, cost assessment, gain estimation, SA familiarity
Action Implementatio n	Act, planning, resource mgt., constraints ID, project mgt.	Set of Actions, schedule, milestones, plan, mission, orders	Feasibility, acceptability, resource available

3.3 The Cognitive process included in the C-OODA

From the M-OODA architecture, the C-OODA has been developed by Breton [11]. The objective of the C-OODA is to increase the level of granularity of the OODA loop by formulating a detailed cognitively valid representation of the C2 decision cycle, the C-OODA. [16] It also provides more details on the control component of the M-OODA. According to Breton, the control is based on the time available in the situation and the level of uncertainty in the situation. For instance, if the level of uncertainty is high, but there is no time left for further processing, the cognitive processing of the C-OODA is stopped. Figure 9 presents the different types of states resulting from the different processes included in the C-OODA (blue boxes).

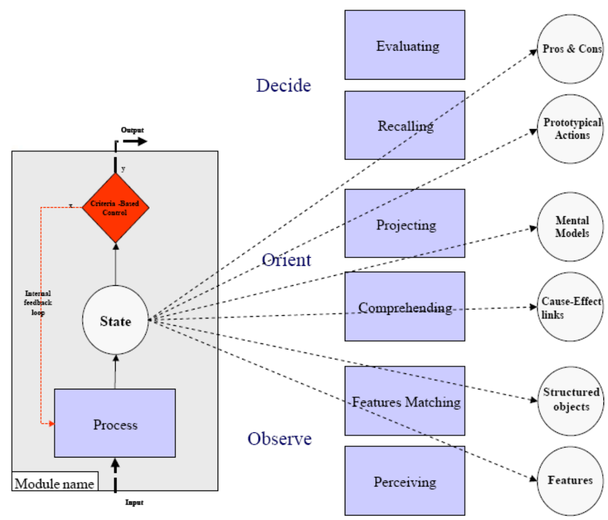

Figure 9. C-OODA Control states.[11]

The C-OODA model divides up the cognitive decision-making cycle. Other approaches to modeling user cognitive decision making include categories of: neglect, consult, rely, and interact. [45] In each case, the user evaluates the output. The five basic user refinement functions of (1) Planning, (2) Organizing, (3) Coordinating, (4) Directing, and (5) Controlling [47] relate to the cognitive action by varying the time required for each C-OODA process activity.

4 Simulation

In this simulation, we assess the C-OODA for decision making based on the time to make a response. In decision making analysis, there are three types of responses (knowledge, skills, rules) which are cognitive reasoning, rule-based perceptual actions, and physical execution that alter the estimated timeliness of action.

In Rasmussen's model [46, 47], user goals are determined from the decision desired. To achieve the correct goal, planning of actions and situation identification is performed at the *knowledge* level. Once a situation or task is learned, *rules* can be instantiated as to the recognition of features to be associated from one situation to the next. Such a case is when a human is proactive to receive data inputs for pre-established rules of behavior. One the rules are in place, the user can utilize *automatic* actions to data inputs to allow for faster response time performance. The depiction of the Rasmussen's levels is shown in Table 4.

Table 4: Behavior Representation and Process-Rules

Behavior	**Representation of Problem Space**
Knowledge-Based (Cognitive)	Mental model; explicit representation of relational structures; part-whole, means-end, causal, generic, episodic, etc. relation
Rule-Based (Perception)	Implicit in terms of cue-action mapping; black-box action-response models
Skill-Based (Physical)	Internal, dynamic model representing the environment and the body in real time

Behavior	**Process-Rules**
Knowledge-Based (Cognitive)	Heuristics and rules for model creation and transformation: mapping between abstraction levels: heuristics for thought experiments
Rule-Based (Perception)	Situation-related rules for operation on the task environment, i.e., on physical or symbolic objects
Skill-Based (Physical)	Not relevant - an active simulation model is controlled by laws of nature, not by rules

Control theory is a popular method to analyze mechanical, biological, and psychological systems. [48] There are many algebraic models that empirically collect data from human-factor studies and perform a regression analysis to parameterize the effects.[1] In this case, we are concerned about the timeliness to afford a user with a decision threshold from which control models are a candidate model. Control models assess state estimation accuracy or stability (time to converge). In the C-OODA model, the human is engaged into an iterative process with the objective of reducing information uncertainty. Such a process is stopped when the time required to iterate is higher than the time available or when the information certainty reaches a specific threshold. Using control theory, we develop a model for time responses for an input delay, action, and output delay as shown in Table 5.

Table 5: Specifications of time delays in the C-OODA.

C-OODA	**Input Delay**	**Action**	**Output Delay**
Perception/ Feature Match	Get data	Exponential	Data Processing
Comprehension/ Projection	Organizing data	Ramp	Multiple processes
Recall/ Evaluate	Selection of option	Step	Query Selection
Act	Physical Action	Impulse (Immediate)	Request sent

[1] We appreciate the meta-reviewer clarifications for control theory use within the C-OODA model as an improvement over previous models.

We model the user DM process as a series of linear time invariant (LTI) control operations with feedback, represented in state space as:

$$\dot{\mathbf{x}}(t) = A\,\mathbf{x}(t) + B\,\mathrm{K}\,\mathbf{u}(t)$$
$$\mathbf{y}(t) = C\,\mathbf{x}(t) + D\,\mathrm{K}\,\mathbf{u}(t) \tag{1}$$

where A is the state matrix, B is the input matrix, C is the output matrix, D is the feedforward matrix, and K is a constant as shown in Figure 10.

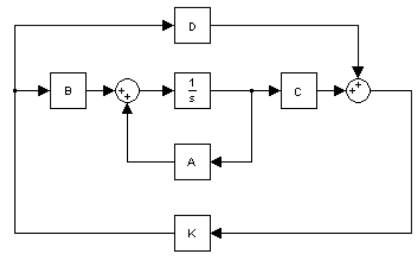

Figure 10. State Space C-OODA Control module.

To model a user function, we utilize a first order system with an exponential response as presented in Figure 11.

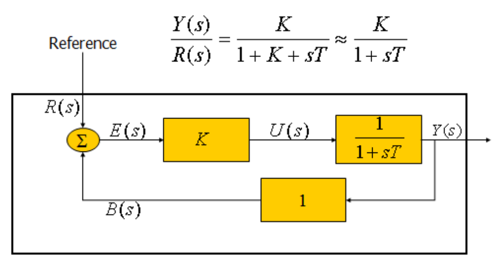

Figure 11. First Order Control model with time delay.

Using the Laplace notation, s, the transfer function has a typical exponential time response:

$$h(s) = \frac{e^{-TDi\,s}}{s+1} \tag{2}$$

We simulate the deadtime for an *input time delay* (TD_i) for a decision i, as related to the user achieving a control decision. Likewise, in the action selection requires time as modeled as an output time delay (TO_i). The updated state-space representation is:

$$\dot{\mathbf{x}}(t) = -A\,\mathbf{x}(t) + B\,\mathbf{u}(t - TD_i)$$
$$\mathbf{y}(t) = C\,\mathbf{x}(t - TO_i) + D\,\mathbf{u}(t) \tag{3}$$

To determine the estimation parameters of A and B, as well as the output analysis of C and D, we model the importance of the information processing as related to the functions in the C-OODA. We note that the transfer function response delays can vary over users and domains which might be difficult to get exact numbers, however, as per human-factor studies; we could get notional times to determine the bottlenecks. For example, Level 1 fusion, Orient, or Comprehension/Projecting requires the most time in analysis (input delay), has the largest impact (amplitude) in the decision making, and takes the most time to provide a set of prioritized actions (output delay). The final step of action selection requires the least amount of delay and amplitude as most other options have been removed to produce a single parameter control loop.

MATLAB Functions:

```
sys1 = ss (A, B, C, D, 'InputDelay',TDi)
sys2 = ss (A, B, C, D, 'InputDelay',TDo)
```

To detail C-OODA modeling, we describe the system time response over the interval that a decision could be made (similar to a probability distribution model for the timeliness of action as represented by the exponential decay). We vary the input and output (I/O) time delays for each component separately, as shown in Figure 12, to model the contributions to the overall time response. Figure 12-14 are *notional* results and serve as a modeling example for real-world collections.

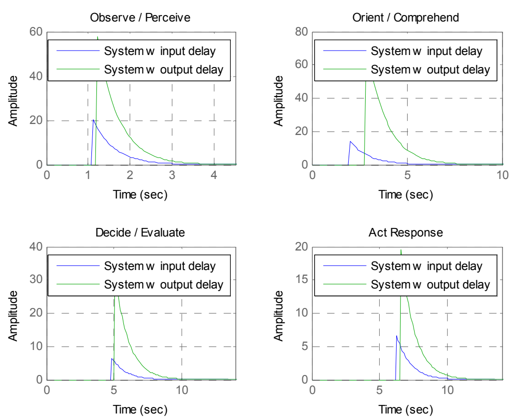

Figure 12. Input/output delay models for the C-OODA.

Figure 13 shows a time response function including the I/O delays used to reach a decision and the ability to evaluate and execute the decision at each C-OODA stage.

Figure 14 details the overall system response as a timeliness analysis of the C-OODA process. An example was simulated in an object recognition task where the C-OODA involves mainly features matching and comprehension (second Observe process and first Orient process). The time to estimate the target classification is based on feature fusion for decision making requiring 9s from observation to target fused classification presentation and user assessment. The user looks at the display and determines what action to take such as tasking another sensor to follow the target. The action decision of which sensor and where to point the sensor requires 13-17s.

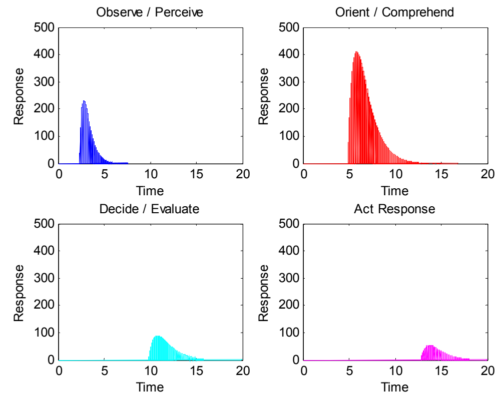

Figure 13. Delay Responses in C-OODA decision fusion.

The methodology and analysis can be used in IFSs evaluations. Using the C-OODA as descriptive model, we can decompose the timeliness of data-to-decision-to-action over the various processes. Determining which processes are most time intensive can aid in future IF system enhancements to augment the user's needs for actionable intelligence. In this example, the peaks in Figure 14 suggest higher time response for matching perceived environmental features and comprehending those features in order to recognize the object.

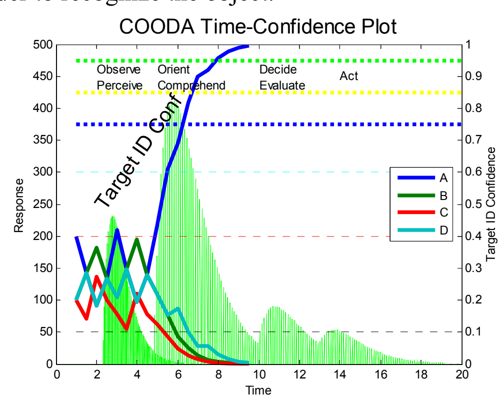

Figure 14. Overall Time Response.

5 Discussion & Conclusions

In this paper, we overviewed the recent developments in information fusion decision making (DM) and action selection models using the cognitive OODA (C-OODA) model. Many developments have progressed from the original Boyd model in DM in the cognitive, psychological, biological, and perceptual literature to instantiate the role of the user in information fusion system design. We advocate the use of the C-OODA which offers a high level of cognitive granularity and a detailed criteria-based control module that include both time and uncertainty as factors in cognitive processing. The C-OODA descriptive C2 model affords a control processing model to coordinate the timeliness of DM between the user and the information fusion evidential reasoning and state estimation machine. The paper looks at a timeliness assessment from data gathering and perception to decision making and action. Future research would evaluate the modeling developments (of which control theory is one choice) of data throughput, estimation accuracy, and evidential confidence from human-factor operational studies to develop pragmatic control interactions between the user and the machine.

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